TITLE OF THE INVENTION

IMAGE PROCESSING APPARATUS AND METHOD, AND RECORDING

MEDIUM

5   BACKGROUND OF THE INVENTION

          This invention relates to an image processing
apparatus and method for performing saturation
conversion.

10   In general, an image processing apparatus for
forming a multi-valued image performs so-called
saturation conversion to obtain an image with
appropriate saturation by compensating saturation for a
less saturated area in an image, and suppressing

15   saturation for an oversaturated area.

          In order to implement saturation conversion in a
conventional image processing apparatus, saturation
values (normally ranging from 0.0 to 1.0) are
calculated in units of pixels in an image, and the

20   saturation value of each pixel is corrected by
multiplying the saturation value by a predetermined
saturation conversion parameter.

          However, the conventional image processing
apparatus always performs saturation conversion based

25   on a saturation conversion parameter with a constant

value regardless of the image feature of the image to be converted.

In general, of colors that the image processing apparatus can reproduce, the flesh tone of a human being, green of plants, blue of sky, and the like are known as colors that a person especially notices and reacts sensitively to their delicate conversion results. Such colors will be referred to as "memory color" hereinafter. Optimal saturation values of these memory color vary depending on their color types. Hence, impression of an image differs depending on the saturation values of these memory color.

Hence, when a process for simply increasing or suppressing saturation at a given rate for the entire image is done regardless of the presence of memory color in the image as in the conventional apparatus, an image which can give good impression to the user cannot always be obtained. That is, it is desired to change the degree of saturation conversion in correspondence with the presence/absence of memory color in an image, or their color types if they are present.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide an image processing apparatus and method, which can implement appropriate saturation

conversion in correspondence with image characteristics, and a recording medium.

According the present invention, the foregoing object is attained by providing an image processing apparatus comprising: characteristic discrimination means for discriminating characteristics of an image; saturation calculation means for calculating saturation information of the image; parameter setting means for setting a parameter used to convert saturation of the image in accordance with the characteristics discriminated by said characteristic discrimination means; and saturation conversion means for converting the saturation of the image on the basis of the parameter.

With this apparatus, the characteristic discrimination means discriminates the image characteristics, the saturation calculation means calculates saturation information of an image, the parameter discrimination means sets a parameter for converting the saturation of the image in correspondence with the characteristics, and the saturation conversion means can convert the saturation of the image on the basis of the set parameter.

The invention is particularly advantageous since saturation conversion can be done in correspondence with the image characteristics.

Other features and advantages of the present invention will be apparent from the following description taken in conjunction with the accompanying drawings, in which like reference characters designate the same or similar parts throughout the figures thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention.

Fig. 1 is a block diagram showing the hardware arrangement of an image processing apparatus according to the present invention;

Fig. 2 is a diagram showing an example of the module arrangement of software according to the present invention;

Fig. 3 is a flow chart showing an outline of an image process in the present invention;

Fig. 4 is a table showing an example of data items held by a parameter holding block;

Fig. 5 is a flow chart showing an image attribute discrimination process;

Figs. 6A and 6B are views showing examples of image attribute discrimination results;

Fig. 7 is a flow chart showing a highlight/shadow calculation process;

Fig. 8 is a graph showing an example of a luminance histogram;

Fig. 9 is a flow chart showing a white/black balance calculation process;

Fig. 10 is a flow chart showing an image correction process;

Fig. 11 is a graph showing an example of the characteristics of a look-up table;

Fig. 12 is a flow chart showing a saturation conversion process;

Fig. 13 is a flow chart showing a color space conversion process;

Fig. 14 is a graph showing an example of saturation conversion characteristics;

Fig. 15 is a graph showing an example of saturation conversion characteristics; and

Fig. 16 is a flow chart showing an inverse color space conversion process.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferred embodiments of the present invention will now be described in detail in accordance with the accompanying drawings.

[Apparatus Arrangement]

5   An example of the arrangement of an image processing apparatus according to an embodiment of the present invention will be described in detail hereinafter with reference to the accompanying drawings. Note that the image processing apparatus of the present

10   invention is implemented by an apparatus comprising the hardware arrangement (e.g., a computer apparatus such as a personal computer), as shown in, e.g., Fig. 1, or by supplying software having functions (to be described later) to a dedicated computer apparatus.

15   Referring to Fig. 1, a CPU 102 of a computer apparatus 100 executes a program stored in a ROM 101 or storage unit 108 such as a hard disk or the like using a RAM 103 and the storage unit 108 as a work memory. The program includes at least an operating system (OS)

20   and software for executing processes (to be described later) according to this embodiment.

Image data to be processed by the computer apparatus 100 is input from an input device such as a digital still camera 107 or the like via an input

25   interface (I/F) 106, and is processed by the CPU 102. The processed image data is converted by the CPU 102

- 6 -

into a format corresponding to an output device, and is then sent to an output device such as a printer 111 or the like via an output I/F 110. The input image data, output image data, image data whose processing is underway, and the like can be stored in the storage unit 108 or can be displayed on a monitor 105 such as a CRT, LCD, or the like via a video I/F 104 as needed. These processes and operations can be designated by the user using a keyboard as an input device, a mouse as a pointing device, and the like connected to a keyboard I/F 109.

Note that the input and output I/Fs 106 and 110 can use SCSI as a versatile interface, parallel interfaces such as GPIB, Centronics, and the like, and serial interfaces such as RS232, RS422, IEEE1394, USB (Universal Serial Bus), and the like.

The storage unit 108 can use storage media such as MO, optical disks (e.g., DVD-RAM), and the like in addition to the hard disk. As a device for inputting image data, a digital video camera, image scanner, film scanner, and the like can be used in addition to the digital still camera, or image data can be input from the storage medium or via a communication medium. As a device to which image data is output, printers such as a laser beam printer, ink-jet printer, thermal printer, and the like, a film recorder, and the like can be used.

Furthermore, the processed image data may be stored in the storage medium or may be output onto the communication medium.

[Functional Arrangement]

5   Fig. 2 is a diagram showing an example of the arrangement of function blocks (modules) of software according to this embodiment. In this embodiment, the functional arrangement that implements saturation conversion in this embodiment comprises an image input

10   block 2, image output block 3, image buffer 4, parameter holding block 5, histogram holding block 6, histogram generation block 7, highlight/shadow calculation block 8, white/black balance calculation block 9, image correction block 10, saturation

15   calculation block 11, saturation conversion parameter setting block 12, saturation conversion block 13, and image attribute discrimination block 15.

The image input block 2 loads an input image 1, and writes it in the image buffer 4. The parameter

20   holding block 5 holds parameters (including saturation conversion parameters) required for correction to be described later. The histogram holding block 6 holds a histogram of image data. The histogram generation block 7 generates a histogram based on image data

25   stored in the image buffer 4, and stores the generated histogram in the histogram holding block 6. The

highlight/shadow calculation block 8 calculates

highlight and shadow points on the basis of the

histogram stored in the histogram holding block 6, and

stores the calculated points in the parameter holding

5   block 5. The white/black balance calculation block 9

calculates white and black balances, and stores them in

the parameter holding block 5. The image correction

block 10 corrects image data stored in the image buffer

4 on the basis of data stored in the parameter holding

10   block 5.

The image attribute discrimination block 15

discriminates the image attributes of image data stored

in the image buffer 4.

The saturation calculation block 11 calculates

15   the saturation of image data stored in the image buffer

4. The saturation parameter setting block 12

determines a saturation conversion parameter on the

basis of saturation information of an image and user

instruction, and stores the determined parameter in the

20   parameter holding block 5. The saturation conversion

block 13 converts the saturation of image data stored

in the image buffer 4 using the saturation conversion

parameter stored in the parameter holding block 5.

The image output block 3 reads out image data

25   stored in the image buffer 4, and outputs it as an

output image 14.

[Outline of Image Process]

Fig. 3 is a flow chart showing an out line of an image process in this embodiment. In step S1, the image input block 2 loads an input image 1, and stores it in the image buffer 4. In step S2, the image attribute discrimination block 15 discriminates the attributes of the image on the basis of the image data stored in the image buffer 4. Note that the operation of the image attribute discrimination block 7 will be described in detail later with reference to Fig. 5.

In step S3, the histogram generation block 7 generates a luminance histogram on the basis of the image data stored in the image buffer 4, and stores the generated histogram in the histogram holding block 6.

In step S4, the highlight/shadow calculation block 8 calculates highlight and shadow points of the image on the basis of the luminance histogram stored in the histogram holding block 6. Note that the operation of the highlight/shadow calculation block 8 will be described in detail later with reference to Fig. 7.

In step S5, the white/black balance calculation block 9 calculates the white and black balances of the image data stored in the image buffer 4. Note that the operation of the white/black balance calculation block 9 will be described in detail later with reference to Fig. 9.

In step S6, the image correction block 10 loads the image from the image buffer 4, corrects it in units of pixels, and writes the corrected image again in the image buffer 4. Note that the operation of the image correction block 10 will be described in detail later with reference to Fig. 10.

In step S7, the saturation calculation block 11 loads the image from the image buffer 4 and calculates saturation values in units of pixels. Also, the saturation parameter setting block 12 determines saturation parameters on the basis of the calculated saturation values, and stores them in the parameter holding block 5. Furthermore, the saturation conversion block 13 corrects saturation in units of pixels on the basis of the saturation conversion parameters stored in the parameter holding block 5, and writes the corrected image again in the image buffer. Note that such saturation correction processes will be explained in detail later with reference to Fig. 12.

In step S8, the image output block 3 reads out the image data stored in the image buffer 4, and outputs it as an output image 14.

[Parameter]

The parameters stored in the parameter holding block 5 will be explained below. Fig. 4 shows register items in the parameter holding block. Referring to

Fig. 4, as parameters for white balance adjustment, a
highlight point (LH) of image data, white balance
values (RH, GH, BH) for red, green, and blue, a
corrected highlight point (HP), and a highlight area

5   value are held. Likewise, as parameters for black
balance adjustment, a shadow point (LS) of image data,
black balance values for red, green, and blue, a
corrected shadow point (SP), and a shadow area value
are held.

10   To implement saturation conversion, a
low-saturation side saturation conversion parameter,
and a high-saturation side saturation conversion
parameter are held. Furthermore, attribute dependent
saturation values A, B, and C indicating appropriate

15   saturation values corresponding to individual image
attributes are held. In this embodiment, assume that
attribute dependent saturation values A, B, and C
respectively hold saturation values corresponding to
selected attributes, i.e., flesh tone, green of plants,

20   and blue of sky.

In the initial state of this embodiment, these
parameters are initialized to appropriate values. For
example, "245" is set as the corrected highlight point
(HP), and "10" is set as the corrected shadow point

25   (SP). Note that in this embodiment the highlight area
ranges from 99 to 100%, and the shadow area from 0 to

1%. Also, for example, the low-saturation side saturation conversion parameter is initialized to "40", and the high-saturation side saturation conversion parameter is initialized to "20".

5   Moreover, attribute dependent saturation A corresponding to flesh tone is initialized to "0.4", attribute dependent saturation B corresponding to green of plants is initialized to "0.3", and attribute dependent saturation C corresponding to blue of sky is

10   initialized to "0.4". Note that attribute dependent saturation values A, B, and C can be appropriately changed in correspondence with image characteristics, user request, and the like.

[Image Attribute Discrimination Process]

15   Fig. 5 is a flow chart showing the image attribute discrimination process in the image attribute discrimination block 15. That is, Fig. 5 shows the contents of step S2 in Fig. 3 in detail.

       In step S41, the entire image is segmented into a

20   plurality of blocks. For example, the entire image is segmented into a total of 15 blocks = 3 blocks (vertical) × 5 blocks (horizontal). In step S42, image data of one of the segmented blocks is analyzed to set an attribute of that block.

25   Note that attributes include specific objects such as "person", "flower", and the like, non-objects

such as "sky", "grass", "ground", "general background", and the like, a block, most of which is oversaturated to white (to be referred to as a "white block" hereinafter", an unidentifiable block (to be referred

5   to as "other" hereinafter), and the like. Note that information of such attributes may be pre-stored in, e.g., the ROM 101, or may be stored in the RAM 103, storage unit 8, or the like so that they can be updated. Various methods of discriminating an attribute

10 corresponding to an image block have been proposed, and an attribute may be discriminated using any of such methods. Hence, a detailed description of the discrimination method will be omitted.

Figs. 6A and 6B show examples in which an image

15 is segmented into blocks, and attributes are assigned in units of blocks. Fig. 6A shows an example in which attribute "person" is assigned to the central block of the image, and attribute "other" is assigned to the block underneath that block. Attribute "general

20 background" is assigned to other blocks. In case of this image, the block assigned attribute "person" undergoes saturation conversion so that its saturation becomes "0.4" corresponding to attribute dependent saturation A held in the parameter holding block 5.

25   In Fig. 6B, attribute "sky" is assigned to the two upper rows of blocks, and in the lowermost row of

- 14 -

blocks attribute "other" is assigned to the two left blocks and attribute "ground" to the three right blocks. In case of this image, the blocks assigned attribute "sky" undergo saturation conversion so that their saturation values become "0.4" corresponding to attribute dependent saturation C held in the parameter holding block 5. Note that saturation conversion in this embodiment will be described in detail later.

It is then checked in step S43 in Fig. 5 if attributes are assigned to all blocks. If NO in step S43, the flow returns to step S42.

[Highlight/Shadow Calculation Process]

Fig. 7 is a flow chart showing the highlight/shadow calculation process in the highlight/shadow calculation block 8. That is, Fig. 7 shows the contents of step S4 in Fig. 3 in detail. Fig. 8 shows an example of the luminance histogram generated in step S3 in Fig. 3.

In step S12, a highlight point LH of the image is calculated on the basis of the luminance histogram shown in Fig. 8. Note that the highlight point LH is the lowest luminance value in the highlight area of the image. Hence, in the luminance histogram example shown in Fig. 8, since the luminance range corresponding to the highlight area (99 to 100%) ranges from 230 to 255, the highlight point LH is "230". This result is stored

in a corresponding register in the parameter holding
block 5.

In step S13, a shadow point LS of the image is
calculated on the basis of the luminance histogram
shown in Fig. 8. Note that the shadow point LS is a
highest luminance value in the shadow area of the image.
Hence, in the luminance histogram example shown in
Fig. 8, since the luminance range corresponding to the
shadow area (0 to 1%) ranges from 0 to 14, the shadow
point LS is "14". This result is stored in a
corresponding register in the parameter holding block 5.
[White/black Balance Calculation Process]

Fig. 9 is a flow chart showing the white/black
balance calculation process in the white/black balance
calculation block 9. That is, Fig. 9 shows the
contents of step S5 in Fig. 3 in detail.

In step S21, white balance values are calculated.
More specifically, image data is loaded from the image
buffer 4 in units of pixels, and R, G, and B average
luminance values (white balance values) of pixels whose
luminance values are equal to or higher than the
highlight point LH and equal to or lower than a
corrected highlight point HP are calculated. In the
luminance histogram example shown in Fig. 8, pixels
whose luminance values fall within the area ranging
from LH = 230 to HP = 245 undergo this process. The

obtained average values are stored in corresponding

registers RH, GH, and BH of the parameter holding block

5.

In step S22, black balance values are calculated.

5   More specifically, image data is loaded from the image

buffer 4 in units of pixels, and R, G, and B average

luminance values (black balance values) of pixels whose

luminance values are equal to or higher than a

corrected shadow point SP and equal to or lower than

10   the shadow point LS are calculated. In the luminance

histogram example shown in Fig. 8, pixels whose

luminance values fall within the area ranging from SP =

10 to LS = 14 undergo this process. The obtained

average values are stored in corresponding registers RS,

15   GS, and BS of the parameter holding block 5.

[Image Correction Process]

Fig. 10 is a flow chart showing the image

correction process in the image correction block 10.

That is, Fig. 10 shows the contents of step S6 in

20   Fig. 3 in detail.

In step S31, a look-up table (LUT) is prepared on

the basis of the white balance values (RH, GH, BH) of

the individual colors, highlight point HP, black

balance values (RS, GS, BS), and shadow point LS held

25   in the parameter holding block 5. Fig. 11 shows an

example of the prepared LUT. In the LUT shown in

Fig. 11, the highlight portion has steeper gamma correction characteristics in the order of G, B, and R. In this way, by emphasizing G and B with respect to R, so-called color tint of an image tinged with blue (blue cast) can be corrected.

In step S32, the image data stored in the image buffer 4 is corrected in units of pixels on the basis of the prepared LUT.

[Saturation Conversion Process]

Fig. 12 is a flow chart showing the saturation conversion process as the characteristic feature of this embodiment. This process shows the contents of step S7 in Fig. 3 in detail, and is implemented by the saturation calculation block 11, saturation conversion parameter setting block 12, and saturation conversion block 13.

●Color Space Conversion Process

In step S101, the saturation calculation block 11 converts image data expressed in the RGB color space into HLS data in the HLS color space indicating hue, lightness, and saturation. Fig. 13 is a flow chart showing the process for converting RGB data into HLS data in units of pixels, and this process will be explained below. Note that the present invention is not limited to such specific saturation calculation method, and other methods may be used.

- 18 -

Referring to Fig. 13, a maximum value M and
minimum value m of R, G, and B color component data of
the pixel of interest are obtained (S201). The
obtained maximum and minimum values M and m are

5   compared (step S202). If the two values are equal to
each other, i.e., if R = G = B and the pixel of
interest has achromatic color, the flow advances to
step S204. If the two values are not equal to each
other, the following values are calculated in step

10   S203:

$$r = (M - R)/(M - m)$$

$$g = (M - G)/(M - m)$$

$$b = (M - B)/(M - m)$$

In step S204, lightness L is calculated by:

15     $$L = (M + m)/2.0$$

It is checked if the pixel of interest is
achromatic color or if lightness L is equal to or lower
than a predetermined value (0.5) if the pixel of
interest is not achromatic color (S205, S206), and

20   saturation S is calculated according to the
discrimination result by (S207 to S209):

Achromatic color   : S = 0

Chromatic color L $\leq$ 0.5 : S = (M-m)/(M+m)

Chromatic color L > 0.5 : S = (M-m)/(2.0-M-m)

25   It is then checked if the pixel of interest is
achromatic color or which color component the maximum

- 19 -

value M corresponds to if the pixel of interest is not achromatic color (S210, S211), and hue H is calculated according to the discrimination result by (S212 to S216):

5
    Achromatic color   : H' = 0

    Chromatic color R = M   : H' = 2+b-g

    Chromatic color G = M   : H' = 4+r-b

    Chromatic color B = M   : H' = 6+g-r

    H = 60H' (mod360)

10 Note that the hue of achromatic color is defined to be zero in this embodiment.

As described above, the conversion process shown in Fig. 13 converts RGB data indicating one pixel into HLS data including hue H ranging from 0° to 360° (blue:
15 0°, red: 120°, green: 240°), lightness L ranging from 0.0 to 1.0 (black to white), and saturation S ranging from 0.0 to 1.0 (achromatic color to most vivid color for certain saturation).

•Load Image Attribute

20   In step S102 in Fig. 12, image attribute information of each block discriminated by the image attribute discrimination block 7 is loaded from the parameter holding block 5.

•Saturation Conversion Parameter Setup and Saturation
25 Conversion Process

In steps S103 and S104, the saturation conversion parameter setting block 12 determines low- and high-saturation side conversion parameters, and stores them in the parameter holding block 5.

5   Note that the method of determining the low- and high-saturation side conversion parameters will be described in detail later.

In step S105, the saturation conversion block 13 performs saturation conversion of HLS data of an
10   original image on the basis of the saturation conversion parameters set in steps S103 and S104.

Setups of these two saturation conversion parameters and details of the saturation conversion process using these parameters will be explained below
15   with reference to Fig. 14.

Fig. 14 is a graph showing the saturation conversion characteristics in this embodiment. The abscissa plots the saturation values (0.0 to 1.0) of an original image, and the ordinate plots the converted
20   saturation values (0.0 to 1.0). The abscissa and ordinate respectively also plot low- and high-saturation side conversion parameters, which respectively assume values ranging from 0 to 100, and correspond to conversion lines.

25   In Fig. 14, if the lower left point of the graph that corresponds to saturation = 0.0 of the original

image and to converted saturation = 0.0 is defined as an origin, for example, a low-saturation side parameter = "0" means a line that connects the origin (0.0, 0.0) and the upper right point (1.0, 1.0) of the graph, and a low-saturation side parameter = "100" means a line that connects the origin (0.0, 0.0) and the upper left point (0.0, 1.0) of the graph. By equally dividing each line into 100 sections, lines corresponding to low-saturation side parameter values ranging from 0 to 100 can be obtained. Hence, when the low-saturation side saturation conversion parameter is, e.g., "40", it indicates a line that connects the origin (0.0, 0.0) and a point (0.6, 1.0).

On the other hand, a high-saturation side parameter = "0" means a line that connects the upper right point (1.0, 1.0) and the origin (0.0, 0.0) of the graph, and a high-saturation side parameter = "100" means a line that connects the upper right point (1.0, 1.0) and the upper left point (0.0, 1.0) of the graph. By equally dividing each line into 100 sections, lines corresponding to high-saturation side parameter values ranging from 0 to 100 can be obtained. Hence, when the high-saturation side saturation conversion parameter is, e.g., "20", it indicates a line that connects the upper right point (1.0, 1.0) and a point (0.0, 0.2) of the graph.

Note that Fig. 14 exemplifies the conversion characteristics that increase saturation. Likewise, conversion characteristics that decrease saturation are available. Fig. 15 shows an example of the conversion characteristics that decrease saturation.

Referring to Fig. 15, the abscissa plots the saturation values (0.0 to 1.0) of an original image, and the ordinate plots the converted saturation values (0.0 to 1.0). The abscissa and ordinate respectively plot high- and low-saturation side conversion parameters, which respectively also assume values ranging from 0 to 100, and correspond to conversion lines.

In Fig. 15, if the lower left point of the graph that corresponds to saturation = 0.0 of the original image and to converted saturation = 0.0 is defined as an origin, for example, a low-saturation side parameter = "0" means a line that connects the origin (0.0, 0.0) and the upper right point (1.0, 1.0) of the graph, and a low-saturation side parameter = "-100" means a line that connects the origin (0.0, 0.0) and the lower right point (1.0, 0.0) of the graph. By equally dividing each line into 100 sections, lines corresponding to low-saturation side parameter values ranging from 0 to -100 can be obtained. Hence, when the low-saturation side saturation conversion parameter is, e.g., "-40",

it indicates a line that connects the origin (0.0, 0.0) and a point (1.0, 0.6).

On the other hand, a high-saturation side parameter = "0" means a line that connects the upper right point (1.0, 1.0) and the origin (0.0, 0.0) of the graph, and a high-saturation side parameter = "-100" means a line that connects the upper right point (1.0, 1.0) and the lower right point (1.0, 0.0) of the graph. By equally dividing each line into 100 sections, lines corresponding to high-saturation side parameter values ranging from 0 to -100 can be obtained. Hence, when the high-saturation side saturation conversion parameter is, e.g., "-20", it indicates a line that connects the upper right point (1.0, 1.0) of the graph and a point (0.2, 0.0).

Note that the saturation conversion characteristics shown in Figs. 14 and 15 may be pre-stored in, e.g., the ROM 101, or may be stored in the RAM 103, storage unit 8, or the like so that they can be updated.

The method of determining low- and high-saturation side conversion parameters in this embodiment will be described below.

In this embodiment, when an image includes a block having image attribute "person", the saturation conversion parameters are set so that the saturation of

that block becomes "0.4" corresponding to attribute dependent saturation A held in the parameter holding block 5. Likewise, when an image includes a block having image attribute "plant" or "sky", the saturation

5 conversion parameters are set so that the saturation of that block becomes "0.3 or "0.4" corresponding to attribute dependent saturation B or C held in the parameter holding block 5.

For example, in Fig. 6(a), if the block assigned

10 image attribute "person" has saturation (e.g., average saturation of pixels in a block) = "0.2", that saturation must be converted into "0.4". In this case, since conversion for increasing saturation is required, a point for converting saturation = "0.2" into "0.4"

15 corresponds to point A (0.2, 0.4) on the graph, as can be seen from the lines shown in Fig. 14. Hence, lines that pass through or are closest to point A are set as the saturation conversion parameters. In this case, since lines B and C pass through the vicinities of

20 point A for low- and high-saturation side saturation conversion parameters, "50" and "30" are respectively set as the low- and high-saturation side saturation conversion parameters in steps S103 and S104.

In Fig. 6(b), when the block assigned image

25 attribute "sky" has saturation = "0.5", that saturation must be converted into "0.4". In this case, since

conversion for decreasing saturation is required, a

point for converting saturation = "0.5" into "0.4"

corresponds to point E (0.5, 0.4) on the graph, as can

be seen from the lines in Fig. 15. Hence, by setting

5   lines that pass through or are closest to point E as

the saturation conversion parameters, "-20"

corresponding to lines F and G are respectively set as

the low- and high-saturation side saturation conversion

parameters in steps S103 and S104.

10   On the other hand, if an image includes none of

blocks having image attributes "person", "plant", "sky",

and the like, i.e., if an image has no blocks

corresponding to the attribute dependent saturation

values held in the parameter holding block 5, default

15   values "40" and "20" are respectively set as the

low- and high high-saturation side saturation

conversion parameters in steps S103 and S104.

Based on the two, low- and high-saturation side

conversion lines set in this manner, saturation

20   conversion characteristics actually used in the

saturation conversion process are calculated. For

example, in Fig. 14, when "50" and "30" are

respectively set as the low- and high-saturation side

saturation conversion parameters, the two corresponding

25   lines cross at point D. Hence, in step S105, a line

that connects the origin (0.0, 0.0), point D, and the

upper right point (1.0, 1.0) of the graph is calculated

as the saturation conversion characteristics, and the

saturation (S) component of the HLS data converted in

step S101 undergoes saturation conversion based on the

5   calculated characteristics. According to the

saturation conversion characteristics, the converted

saturation neither becomes 0.0 (achromatic color) nor

is saturated at 1.0.

       In this manner, since different saturation

10   parameters can be set at the low- and high-saturation

sides, oversaturation or undersaturation due to

saturation conversion can be avoided, and appropriate

saturation correction can be achieved at both sides.

●Inverse Color Space Conversion Process

15   After the HLS data has undergone saturation

conversion, the saturation calculation block 11

inversely converts the saturation-converted HLS data

into RGB data in step S106 in Fig. 12. Fig. 16 is a

flow chart showing the inverse conversion process from

20   HLS data into RGB data, and this process will be

explained below.

       Referring to Fig. 16, it is checked if a

lightness value L is equal to or higher than a

predetermined value (0.5) (S301). If YES in step S301,

25   parameter $M = L(1.0 + S)$ is set (S302); otherwise, $M = L + S - LS$ is set (S303). After parameter $m = 2.0L - M$

is set (S304), R, G, and B color component values are
calculated using a function f(m, M, h) by (S305):

$$R = f(m, M, H)$$

$$G = f(m, M, H-120)$$

5 $$B = f(m, M, H-240)$$

Note that depending on the value h, the function
f(m, M, h) is determined by:

$$0 \leq h < 60 \qquad : f(m, M, h) = m+(M-m)h/60$$

$$60 \leq h < 180 \qquad : f(m, M, h) = M$$

10 $$180 \leq h < 240 \qquad : f(m, M, h) = m+(M-m)(240-h)/60$$

$$240 \leq h < 360 \qquad : f(m, M, h) = m$$

Note that if h is a negative value, a value obtained by
adding 360 to h is referred to.

In this manner, the saturation-converted HLS data
15 is inversely converted into RGB data, and the converted
data is held in the buffer 4. Then, the RGB data is
output as an output image 14 (S8).

In this embodiment, the default value of the
low-saturation side saturation conversion parameter is
20 set at "40", and that of the high-saturation side
saturation conversion parameter is set at "20".
However, the present invention is not limited to such
specific default values of the parameters, and any
other values may be set if they fall within an
25 allowable setting range (0 to 100 in the above
embodiment).

Furthermore, the saturation conversion parameters may be directly set according to user instruction. More specifically, the user may change the parameters set by the saturation conversion parameter setting block 12 via the keyboard I/F 109. For example, the user may directly designate an image attribute, and the saturation conversion parameters may be set in correspondence with the designated image attribute.

As shown in Figs. 14 and 15, in this embodiment, the saturation conversion parameters correspond to saturation conversion lines. However, the saturation conversion characteristics of the present invention are not limited to lines but may be defined by curves. That is, appropriate lines or curves need only be set as saturation conversion characteristics so as to achieve appropriate saturation conversion.

As described above, according to this embodiment, since an image attribute is discriminated, and the saturation conversion characteristics can be set in correspondence with the discrimination result, optimal saturation conversion can be implemented in accordance with the image attribute. Especially, saturation conversion can be satisfactorily made in correspondence with memory color such as flesh tone of a human being, and the like that a person notices and reacts sensitively to their delicate conversion results.

Since the saturation conversion characteristics can vary at the low- and high-saturation sides, flexible saturation conversion can be attained, and chromatic color can be prevented from becoming achromatic at the low-saturation side or being saturated at the high-saturation side as a result of saturation conversion.

<Modification>

In the above embodiment, only one of attributes "person", "plant", and "sky" appears in the image to be converted. However, two or more image attributes (e.g., "person" and "sky") are highly likely to be assigned to one image. In such case, no problem is posed if a saturation conversion parameter common to the plurality of attributes can be set, and saturation conversion which can satisfy all the assigned attributes can be achieved.

However, if a common saturation conversion parameter cannot be set, priority must be set among attributes. For example, priority may be set in the order of "person" > "sky" > "plant". Of course, the present invention is not limited to such specific priority order, and priority can be arbitrarily set in correspondence with the type of scene of an image, the image forming situation in the image processing apparatus, or user request.

In the above embodiment, three different attributes "person", "plant", and "sky" are weighted upon saturation conversion, and attribute dependent saturation values corresponding to these attributes are held in the parameter holding block 5. However, attribute dependent saturation values corresponding to other attributes such as "sea" and the like may be added to the parameter holding block 5.

Furthermore, attribute "person" which corresponds to flesh tone may be divided into "white race", "black race", "yellow race", and the like, and attribute "sky" may be divided into "cloudy", "fine" "evening glow", "night sky", and the like, and corresponding attribute dependent saturation values may be added. That is, optimal saturation values corresponding to individual attributes can be set in the parameter holding block 5.

The number of segmented blocks upon image attribute discrimination is not limited to 3 × 5 blocks in the above embodiment. For example, the image may be segmented into still smaller blocks such as 5 × 7 blocks and the like, or the number of segmented blocks may be adaptively determined in consideration of the aspect ratio of an image. Furthermore, the shape of one block is not limited to a rectangular shape, but may be a triangular shape, hexagonal shape, trapezoidal shape, and the like.

In the above embodiment, the saturation
conversion parameters are set so that the average
saturation of pixel in a given block assigned a
predetermined attribute becomes a predetermined value.
5   Alternatively, a principal object in a given block may
be extracted by a known recognition technique, and the
saturation conversion parameter may be set based on the
average saturation of only pixels that form the
principal object. In this manner, correction which is
10   free from any influences of the background and is
optimal to the principal object can be achieved.
[Other Embodiments]

Note that the present invention may be applied to
either a system constituted by a plurality of devices
15   (e.g., a host computer, an interface device, a reader,
a printer, and the like), or an apparatus consisting of
a single equipment (e.g., a copying machine, a
facsimile apparatus, or the like).

The objects of the present invention are also
20   achieved by supplying a storage medium, which records a
program code of a software program that can implement
the functions of the above-mentioned embodiments to the
system or apparatus, and reading out and executing the
program code stored in the storage medium by a computer
25   (or a CPU or MPU) of the system or apparatus. In this
case, the program code itself read out from the storage

medium implements the functions of the above-mentioned embodiments, and the storage medium which stores the program code constitutes the present invention. As the storage medium for supplying the program code, for example, a floppy disk, hard disk, optical disk, magneto-optical disk, CD-ROM, CD-R, magnetic tape, nonvolatile memory card, ROM, and the like may be used.

The functions of the above-mentioned embodiments may be implemented not only by executing the readout program code by the computer but also by some or all of actual processing operations executed by an OS (operating system) running on the computer on the basis of an instruction of the program code.

Furthermore, the functions of the above-mentioned embodiments may be implemented by some or all of actual processing operations executed by a CPU or the like arranged in a function extension board or a function extension unit, which is inserted in or connected to the computer, after the program code read out from the storage medium is written in a memory of the extension board or unit.

When the present invention is applied to the storage medium, that storage medium stores program codes corresponding to the aforementioned flow charts (Figs. 3, 5, 7, 9, 10, 12, 13, and 16).

As many apparently widely different embodiments of the present invention can be made without departing from the spirit and scope thereof, it is to be understood that the invention is not limited to the

5   specific embodiments thereof except as defined in the appended claims.